34. The Life-History and Habits of the Yellow Dung-Fly (*Scatophaga stercoraria*); a possible Blow-Fly Check. By G. S. Cotterell. With a Preface by Prof. Maxwell Lefroy, F.Z.S.*

(Text-figures 1–14.)

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Preface.

This paper is an account of work undertaken to complete an inquiry into Blow-fly control, of which a partial account has already been published by Mr. A. M. Altson in the Proceedings of the Zoological Society, 1920, p. 195. Of the three important controls of Blow-fly in England, Mr. Altson has already dealt with the two common parasites: the present paper deals with what we believe to be the most important direct enemy of the adult fly, a check which appears to be very effective in this country. The Yellow Dung-fly first showed itself in our work at the Zoological Society in 1915 in connection with methods of trapping flies: it came in numbers, persistently eating the adult Blow-flies, and seriously interfered with experiments out of doors. My observations since show that while the fly preys on a large variety of Diptera, it specially attacks *Calliphora* and *Musca*. It is a constant and general feeder on the common species of Blow-fly in England throughout the season.

The author of this paper undertook the investigation, and submitted this paper as a thesis for the Diploma of the Imperial College: he also investigated the best means of transporting this species to countries where Blow-fly is a serious pest to sheep, in the hope that it might be possible to utilise it as a check on Blow-fly. This has not been possible as yet, but the species seems to have much value in this connection, and its habits as a maggot and an adult are so harmless that it is to be hoped it will eventually be made use of.—H. M. Lefroy.

Introduction.

The study of the life-history and habits of the Yellow Dung-fly was first commenced in October 1919, at a time when the Blow-fly problem was receiving a great deal of attention and the discovery of an efficient control was sought for.

In conjunction with other methods of control then under investigation, that of the Yellow Dung-fly, as a predator on the Blow-fly, was also studied.

The adult fly was identified for me by Mr. Edwards, of the Natural History Museum, South Kensington, as *Scatophaga*

* Communicated by Prof. Maxwell Lefroy, F.Z.S.

stercoraria L., belonging to the family Cordyluridæ of the Acalyptrate Diptera.

A description of the species is given in a monograph by Becker, which is at present the standard work on the classification of the family Cordyluridæ.

Both sexes vary from very large and robust flies to small varieties. The largest measures 15 mm. in length and the smallest 8 mm. The span of the wings is over double the length.

The head is globular; the eyes oval, brown, and separated in both sexes by an area equal to half the width of the head. The frontal stripe is rich yellowish brown in the male, dull yellow in the female. The frontal margins of the orbits, cheeks, and face are yellow. The facial bristles are strong; antenna black, and the arista bare except for the upper third, which is feathered.

The thorax of the male is marked with longitudinal stripes on the dorsal surface. There is a bunch of light yellow hairs under each wing. The thorax of the female is coloured darker, the stripes more marked, and the hairs below the wings are absent. Both sexes have more than two rows of acrostical bristles, and well-marked scutellar bristles.

The wings are slightly yellow; anterior cross-veins very distinct, with a smoky coloration round them.

The femora are covered with long yellow hair in the male, especially the anterior pair; other parts yellow but not hairy. In the female the femora are dark and clothed with a few dark hairs.

The abdomen of the male is yellow and very hairy. In the female yellow-green and not hairy. The male abdomen is cylindrical, terminating bluntly. There is a dark area on the ventral surface of the fifth segment marking the entrance to the male genital atrium. In the female it is short, broad at the base and conical, becoming more or less oval when gravid.

The female is smaller than the male and darker, owing to the absence of the yellow hairs. The legs of both sexes are bristly and the pulvilli well developed.

The sexes are distinguished by the size, difference in colour, shape of the abdomen, and the black area on the ventral surface of the abdomen of the male.

There are nineteen British species of the genus, but I have never observed any other breeding in dung.

S. merdaria is the nearest related species, but is distinguished by both sexes being dirty green in colour and by there being only two rows of dorso-central bristles on the thorax.

S. scybalaria is distinguished by the colour of the third antennal joint, which is reddish brown.

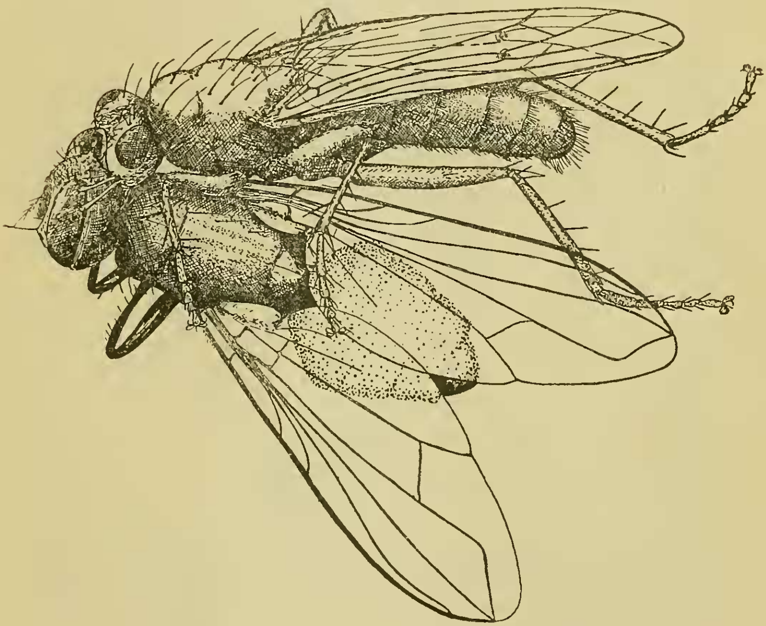
Scatophaga stercoraria is widely distributed. It occurs as far north as Nova Zembla and Siberia, and as far south as North and South Africa and the Canary Islands. It is common throughout Europe and is found in Asia Minor. I have seen no mention of it occurring in India or Australia.

It is evidently both a temperate and sub-tropical species.

Adult Feeding.

Both sexes of the adult fly are predaceous on other Diptera. The prey is never caught on the wing, but usually at the moment of settling. The captured fly is grasped firmly by the middle and hind legs, the bristles of the legs helping to make a firmer grip. The prey is caught in such a fashion as to bring both flies in an upright position and the heads one above the other. In this position the wings of the victim are useless, its legs being the only active part. The proboscis is then pressed against the neck and a puncture made through both sides. Attacked flies may all

Text-figure 1.



Scatophaga stercoraria, ♂, attacking *Musca domestica*.

be seen to have the neck stretched and a distinct hole right through it. In this way the nerve-cord is either cut or damaged, causing a partial paralysis. The contents of the thorax are then sucked out, at the junction of the neck, as far as the proboscis will reach. A large amount of saliva is secreted during these operations, probably acting as a solvent. The head is then turned round by means of the front legs, bringing the oral margin uppermost. Another puncture is made inside the oral margin, and the contents of the head, including the eye-pigment, are also sucked out. Access to the other parts of the thorax is obtained through the thinly-chitinised membranes between the coxæ and thorax. The fly is then turned completely round, bringing the ventral surface of the abdomen uppermost and the head in a posterior position. The contents of the abdomen are then sucked out through punctures between the sternites.

This order of feeding is invariably carried out, but, when food is abundant, the parts are only partially sucked out, the abdomen often not being touched.

Attraction for more food from one victim apparently ceases when struggling has ceased.

Both sexes are very strong in flight and are capable of flying short distances, grasping flies as large as themselves.

Adult Mouth-parts.

On account of its predaceous habits the mouth-parts are modified accordingly.

Externally the proboscis is of the Muscid type, *i. e.* the ordinary labella consisting of the fused inner lobes of the labium, the pseudo-tracheæ, the labrum-epipharynx, hypopharynx, and maxillary palpi. These structures are identical with those found in *Musca domestica* or *Calliphora erythrocephala*, in which the proboscis is adapted for licking. The only modifications due to its predaceous habit are found in the internal chitinised structures of the labellum, or oral disc, and haustellum.

The structure of the rostrum, or proximal portion of the proboscis, is identical with that of *C. erythrocephala* as described by Lowne. The main chitinised structure is the fulcrum (text-fig. 2, *a*) enclosing the pharynx. This has been compared by Kraepelin to a Spanish stirrup-iron with a double foot-plate, the foot-plate being posterior and the toe at the lower end. The whole structure of the rostrum resembles that of a truncated cone with the apex downwards.

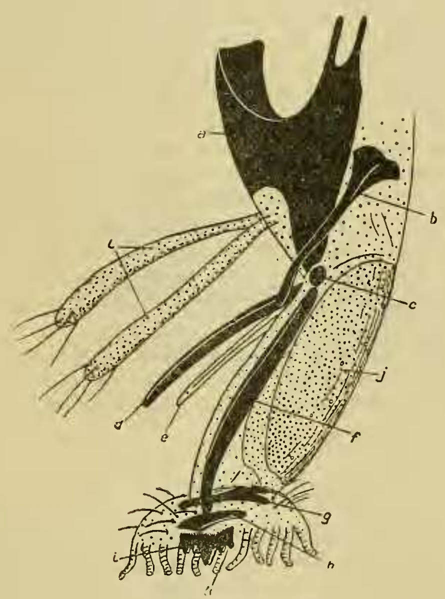
The haustellum or arm of the proboscis is cylindrical in shape. Proximally it is attached to the lower end of the rostrum, and distally to the oral disc. It is enclosed on its lateral and ventral sides by a convex sclerite, the theca (text-fig. 2, *j*). This articulates proximally with the fulcrum and distally with the furca (text-fig. 2, *g*), a tri-radiate sclerite forming the chief internal skeletal structure of the oral disc.

The labrum-epipharynx (text-fig. 2, *d*) and hypopharynx (text-fig. 2, *e*), enclosing the salivary duct, lie over the dorsal portion of the haustellum as in the House-fly.

The oral disc consists of two lobes united posteriorly by a ball-and-socket joint, each grooved on its oral surface by a number of pseudotracheæ (text-fig. 2, *k*). The oral aperture is situated between the lobes at their point of junction. A space below the mouth is kept open by a pair of sclerites, the discal sclerites (text-fig. 2, *h*), deeply embedded in the oral disc. These sclerites are united posteriorly, forming a U-shaped structure. This space is the oral pit, and the common trunks of the pseudotracheæ open into this.

Up to this point the structure, except for minor details, is identical with that of the Blow-fly or House-fly. In addition, however, the haustellum is strengthened by a pair of long, chitinised rods (text-fig. 2, *f*), articulating proximally with the fulcrum and distally with the discal sclerites. These occur also in the House-fly and Blow-fly, but are only very slender rods.

Text-figure 2.



Mouth-parts of adult:—*a*, fulcrum; *d*, labrum-epipharynx; *e*, hypopharynx; *f*, rods; *g*, furca; *h*, discal sclerite; *i*, teeth; *j*, theca; *k*, pseudotracheæ.

They play an important part in the articulation of the oral disc. In this case the oral disc is extremely mobile and used for rasping as well as sucking, therefore the rods are more strongly developed. These rods are called paraphyses by Lowne in his description of the Blow-fly.

The paraphyses articulate distally with the discal sclerite: thus, there are two articulation points between the haustellum and oral disc—the first between the theca and furca, and the second between the paraphyses and the discal sclerite.

To each arm of the discal sclerite a set of teeth is attached (text-fig. 2, *i*). Each set consists of five teeth, the middle one being the most prominent. They are placed on each side of the oral aperture between the two lobes of the oral disc. They probably correspond to the teeth in the House-fly, forming the lateral edges of the gutters or continuations of the common trunks of the united pseudotracheæ described by Graham-Smith. There are three rows on each side of the oral pit in the House-fly, but only one pair on each in *Scatophaga*. They function to a very small extent for rasping in the House-fly, and in *Scatophaga* they exist essentially for rasping. If this point is correct, the mouth-parts are identical with those of the sucking Muscids, except for certain modifications of the chitinised structures, particularly of the paraphyses and teeth, in accordance with its predaceous habits.

The method of sucking is similar to that of the Blow-fly or House-fly. The liquid food is sucked up through the pseudotracheæ into the oral pit and so into the mouth.

By the alternate upward and downward movement of the paraphyses the oral disc is worked in a backward and forward direction, and, consequently, a rasping is caused by the teeth on any surface they are in contact with. In this manner the thinly-chitinised parts of other Diptera are easily punctured. The internal tissues are broken down by further rasping, and apparently partially dissolved by the large amount of saliva secreted. The liquid food is then sucked up through the pseudotracheæ.

The theca serves not only as an external skeleton to the haustellum, but also protects it from whatever damage it might incur from coming in contact with the jagged edges of chitin when inserted in a hole in its victim.

Breeding Media.

The breeding media consist entirely of excrement providing a sufficient consistency for the larva to complete its life without it becoming dry. This includes human excrement, poultry, sheep and cattle excrement, and horse excrement. The last-mentioned is very rarely used for oviposition. Sheep and cattle excrement is preferred chiefly on account of its viscosity and the amount obtainable in pastures. Cattle excrement was used in the breeding-jars in the laboratory.

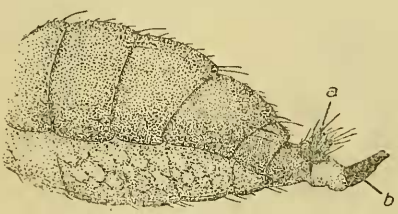
(At the Royal Naval Cordite Factory at Holton Heath a large mass of sludge accumulated from septic sewage tanks: this sludge was in the open, and was about the consistency of fresh cow-dung; it contained an enormous number of this fly in all stages of development, and formed a very suitable breeding medium. I believed that the marked absence of House-flies and Blow-flies at Holton Heath was in part due to this, but I had no direct evidence.—H. M. L.)

Female Genitalia and Method of Oviposition.

As seen externally, the apex of the abdomen of the female ends in two setiferous lobes (text-fig. 3, *a*), between which the anus opens. Below this again is the retractile ovipositor (text-fig. 3, *b*). This consists of a pair of chitinised blades attached, proximally, to a membranous tube. The whole of this can be retracted within the abdomen. The blades are pointed and, when placed together, form a groove. The common oviduct, which is very large, opens into it.

When oviposition is about to take place, the abdomen is stretched out horizontally with the ovipositor extruded. In this position an egg is passed down into the groove formed by the juxtaposition of the two blades of the ovipositor. Ovipositor and egg are then pressed down into the dung obliquely. The blades are pulled apart and the egg released.

Text-figure 3.



Abdomen of female *S. stercoraria*, with genitalia extended.

The eggs are more or less scattered over the surface of the dung, but ten or fifteen or more may be deposited in one small area, particularly where there is a crack or a crevice where the softer parts of the dung are exposed.

Fresh dung is preferred by the females for oviposition, but occasionally eggs are laid in dung a week or more old. In this case the crust on the surface of the dung is too hard for the ovipositor to be inserted deeply, and eggs are often seen only half buried. This does not prevent the egg from hatching, but the larva usually has difficulty in getting through the hardened crust of the dung.

Oviposition occasionally takes place with the male *in situ*, in which case the male removes his abdomen from that of the female, and, instead of clasping her with his two front pairs of legs, drops back clasping her only with the front pair. The female then can manipulate her abdomen freely whilst the male follows her about.

When a female is gravid, the abdomen is so distended as to make her practically incapable of flight. The abdomen is reduced to nearly a fourth its size when oviposition has taken place.

The Egg.

The egg is creamy-white when first laid, becoming darker as the incubation period increases. It measures from 2 to 3 mm. in length and is slightly curved.

It is especially characteristic in having two wing-like extensions of the chorion at its anterior end (text-figs. 4 & 5, *a*). These are covered with extremely short setæ on their under surfaces, and serve as a support in the dung. The egg is laid obliquely at an angle of from 15° to 25° with the surface of the dung, so that the two extensions lie flat on the surface. The micropyle (text-figs. 4 & 5, *c*) is situated between the extensions, and is drawn out into a short crest (text-figs. 4 & 5, *b*) at the anterior end between the two extensions. Its surface is finely sculptured. The two extensions and the micropyle are all

Text-figure 4.

Text-figure 5.

Text-fig. 4.—Egg of *S. stercoraria*, showing supporting wings.
Text-fig. 5.—Hatched egg of *S. stercoraria*.

exposed on the surface. The wall at the base of the egg (text-fig. 5, *e*) is thickened, giving greater strength, as this is the part of the egg which first comes into contact with the dung when oviposition is taking place. The egg is broken by means of a transverse split behind the micropyle (text-fig. 5).

In summer the whole surface of a deposit of cow-dung may be seen covered with the wing-like extensions of the eggs. The incubation period varies from one to two days according to temperature. This period is much more constant than other periods in the life-history, as temperature is the only governing factor.

The newly-hatched larva breaks the egg behind the micropyle, crawls out on to the surface of the dung, and seeks a convenient crack by which to gain access to the softer parts of the dung. This may take some considerable time if the dung has been deposited for some time, and consequently become dry on the surface.

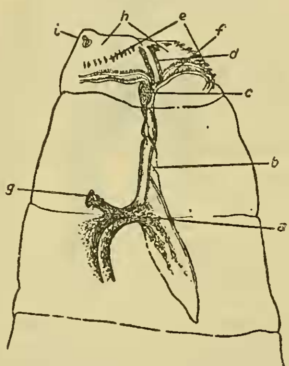
A number of newly hatched larvæ perish through not getting in before they starve.

The Larva.—First Instar.

The larva immediately after hatching measures from 2 to 3 mm. in length. The body is cylindrical, composed of twelve segments, and generally tapers to a point at the anterior end. The posterior end is truncate, forming the anal plate. In this stage the larva is metapneustic, the two spiracles being placed side by side on the anal plate. Each consists of a chitinised ring, situated on a pair of short projections from the anal plate, enclosing two slit-like apertures. The anal plate is bordered by a number of tubercles, the position of which will be described in a later instar.

The first four segments are devoid of spines. Very delicate spines occur on the anterior border of each segment from the fifth posteriorly. The area covered on each segment increases proceeding posteriorly, the whole surface of the last two segments being uniformly covered.

Text-figure 6.



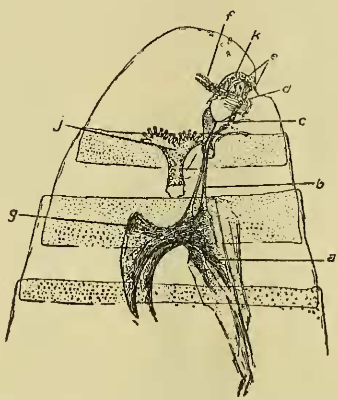
Larva of *S. stercoraria*. 1st instar.

The first segment is divided dorso-ventrally by a cleft forming the two oral lobes (text-fig. 6, *h*). Each lobe carries a pair of sense tubercles (text-fig. 6, *i*). In addition, the ventral surface of the first segment is provided with a transverse row of strong backwardly-curved spines (text-fig. 6, *e*). These are locomotory in function. Keilin mentions them as being present in the first instar larva of *Musca assimilis*. Below the spines there are two channels running more or less parallel with each other. They originate at the mouth, and run out laterally over the ventral surface of the first segment. They are fringed with hair, and direct the liquid food towards the mouth (text-fig. 6, *f*).

The chitinised mouth-parts are slender. Commencing posteriorly there are a pair of **U**-shaped sclerites (text-fig. 6, *a*) with the arms directed backwards. The anterior end of each is extended (text-fig. 6, *b*) for articulation with a large median sclerite (text-fig. 6, *c*). The posterior sclerites, which correspond to the lateral pharyngeal sclerites of the full-grown larva, are united dorso-laterally by a chitinised band (text-fig. 6, *g*). A pair of sclerites are also found embedded in the first segment (text-fig. 6, *d*). These probably correspond to the buccal sclerites or hooks of the full-grown larva. They articulate at their bases with the median sclerite and give rigidity to the oral lobes.

The hooks of the second instar appear behind those of the first a few hours before ecdysis, and become functional as locomotory organs (text-fig. 7).

Text-figure 7.



Larva of *S. stercoraria*. 1st and 2nd instars.

The anterior and posterior spiracles and the remainder of the mouth-parts of the second instar do not appear until just before the moult. An entirely new set of mouth-parts can be seen in a preparation made an hour or so before the moult.

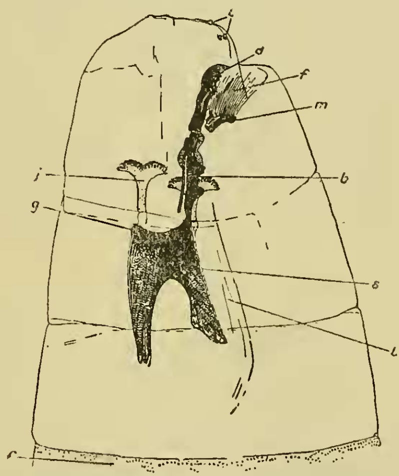
Ecdysis takes place on the first or second day after hatching, the instar lasting from one to two days.

During this instar the larva is very active. In the jars used in the laboratory, occasionally the larvæ hatched out into too liquid dung to allow of a sufficient supply of air below the surface. They were observed to be hanging on to the surface-film with their posterior spiracles exposed, disappearing on being disturbed, reappearing later in the same place. On one occasion the dung remained sufficiently moist to necessitate this during the first two instars. It was only when the third instar was reached that a sufficient air-supply was obtainable below the surface. Probably under natural conditions, where the dung is exposed to wind and other drying factors, it would dry up to a sufficient consistency for the larva to commence living a normal existence buried in the dung itself.

The Larva.—Second Instar.

After the first ecdysis the larva increased considerably in size. It measures from four to six millimetres in length. The general shape of the body and the number of segments remain constant throughout larval life. It is now amphipneustic, being provided with an anterior pair of spiracles (text-fig. 8, *j*) in addition to the posterior pair. The anterior spiracles are situated at the junction of the second and third segments, and will be described in detail in the following instar. The posterior pair are identical with those described in the preceding instar.

Text-figure 8.



Larva of *S. stercoraria*. 2nd instar.

The locomotory spines on the first segment in the previous instar have now disappeared. Spines similar to those of the first instar but proportionately larger occur on each segment behind the fourth. They are concentrated on the anterior border of the fifth, sixth, and seventh segments, but the area covered increases posteriorly. The last few segments are uniformly covered.

The first segment is similar to that described previously, but the locomotory spines are absent. Also the two parallel channels converging into the mouth are now replaced by a number of channels radiating from the mouth over the ventral surface of the oral lobes (text-fig. 8, *f*).

The chitinised mouth-parts have no similarity with those described previously, except for the structure of the lateral pharyngeal plates (text-fig. 8, *a*). These are similar in structure, but are more strongly chitinised and longer in proportion to their breadth. They are united dorsally by a chitinised band, and ventrally by a thinly-chitinised membrane forming the floor of the pharynx (text-fig. 8, *l*). The median piece is replaced by a pair of chitinised rods, the intermediary sclerites (text-fig. 8, *b*), which are united transversely by a bar of chitin. Dorsal to each intermediary sclerite and lying close up to each there is a slender chitinised rod.

The buccal sclerites are elongate and spoon-shaped (text-fig. 8, *d* & text-fig. 9). The exterior lateral edge of each bears four teeth. Ventrally, and at the base of the hooks, there are a pair of short chitinised rods (text-fig. 8, *m*) which support the oral opening.

The buccal sclerites of the third instar appear dorsally to those of the second instar two days before ecdysis, becoming fully chitinised and functional one day before ecdysis. The remainder of the mouth-parts do not become fully chitinised until a few hours before ecdysis. A complete second set of mouth-parts was never definitely observed at this moult, but as all the mouth-parts of the first instar are thrown off, the same may be taken for granted to occur here. The new anterior and posterior spiracles can also be seen underlying those of the present instar.

The second ecdysis takes place on the third and fourth day of larval life, this period lasting from 36 hours to 3 days.

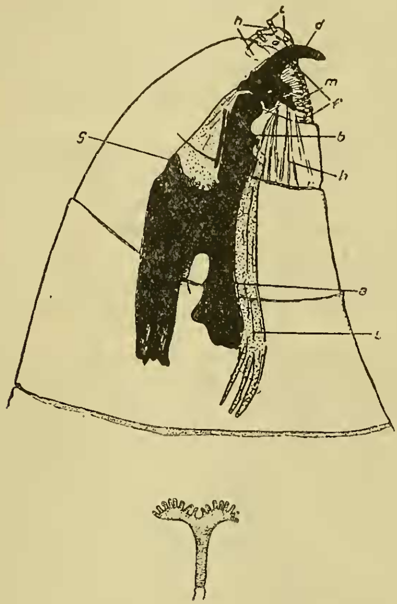
The Larva.—Third Instar.

In the third and final larval instar the larva increases greatly in size, measuring, when full-grown and fully-extended, from one to one and a half centimetres in length. The general external shape is similar to that described in the preceding instars.

The anal plate (text-fig. 11) is surrounded by twelve tubercles. The two largest are situated further forward than the rest on the ventral surface of the last segment immediately behind the anus. The remainder are situated on the border of the anal plate, eight laterally (four on each side) and two dorsally. In addition, there are three situated on the anal plate itself below the spiracles.

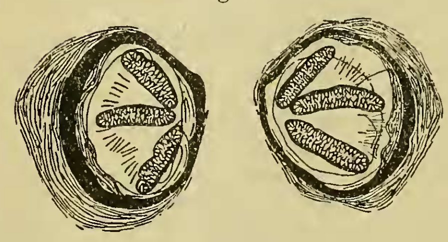
Spines (text-fig. 12) occur on each segment from the fifth segment posteriorly, concentrated on the anterior border. The last few segments are uniformly covered. A belt of spines also occurs round the middle of the fourth segment. The anterior borders of the four anterior segments bear a number of small projecting plates (text-fig. 13) arranged in a number of concentric rings round the segment. Each plate lies against the side of the body, but is hinged anteriorly and can be pushed away from the body. These help to give the first segments a grip when pushed into the dung, but they can also be pulled in against the side of the body if the larva wishes to withdraw its anterior segments. They are to be contrasted with the spines covering the remainder of the body, which also help to give the segments a grip on the sides of the larval burrow, but, being fixed, prevent a backward movement. If the anterior segments were covered with these, the

Text-figure 9.



Larva of *S. stercoraria*. 3rd instar.

Text-figure 10.



Posterior spiracles. 3rd instar.

larva, once having pushed its head in one direction, would be obliged to continue whether it wanted to or not. The hinged plates give it a chance to make a second investigation in another direction provided that it has not gone too far.

The first segment is divided into two oral lobes with radiating food-channels on their ventral surfaces as in the preceding instar.

The chitinised mouth-parts are similar in general structure to those of the second instar, but are proportionately stronger. The lateral pharyngeal sclerites are longer and more deeply cleft (text-fig. 9, *a*). The intermediary sclerites are much thickened and shortened. The buccal sclerites (text-fig. 9, *d*) have no similarity with those of the second instar. They have lost the spoon-shaped structure, and are now a pair of stout ventrally curved hooks. They are pointed anteriorly and thickened where they articulate with the intermediary sclerites. They project externally over the oral opening.

The anterior spiracles (text-fig. 9) are situated laterally at the junction of the second and third segments. They consist of a short chitinised trunk, projecting forwards and externally from the junction of the segments. The trunk divides into two lobes, each lobe bearing usually eight papillæ, making sixteen in all. Each papilla is pierced by a small lumen for the ingress of air. The number of papillæ varies from sixteen to eighteen in different larvæ.

The posterior spiracles (text-fig. 10) are situated side by side in the middle of the anal plate. Each consists of a chitinised ring, situated on a short projection, enclosing three slit-like apertures. The apertures are bordered by inwardly projecting filaments serving as a sieve for the incoming air. These spiracles are the most necessary to the larva, being those it keeps above the surface-film when living in very liquid dung. The respective anterior and posterior spiracles are connected by two lateral longitudinal tracheal trunks. The lateral trunks are connected, soon after their origins from the posterior spiracles, by a transverse trunk. In addition the longitudinal trunks give off small branches in each segment.

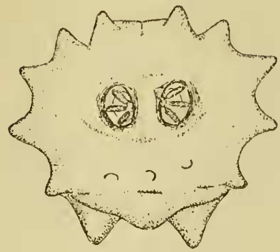
The anus is situated on the triangular plate on the ventral surface of the last segment. This plate is devoid of spines, and appears to be glandular in structure.

The third instar period takes from 6 to 9 days, pupation taking place on the ninth to twelth day of larval life.

The larva is active only during the first two days of this instar, after which it seeks the drier parts of the dung or the soil, preferably the latter. During the inactive period it changes from a more or less transparent appearance to an opaque one, due to the great development of the fat-body.

Great difficulty was experienced in determining whether the whole of the chitinised mouth-parts were thrown off at ecdysis. Owing to the thin epidermis and the impossibility of finding cast skins in the dung, a set of old mouth-parts was never found. Theoretically the complete set should be thrown off, and recently I had the good fortune to mount a preparation within an hour or so of the first moult showing a complete second set outside the old set. Up to this time I had proof that the buccal and

Text-figure 11.

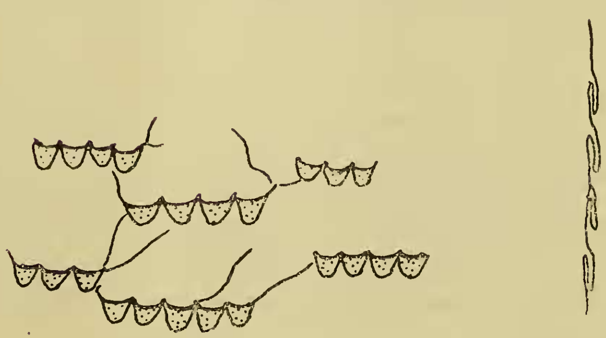


Schematic drawing of anal plate.

Text-figure 12.

Spines of fifth and later segments.

Text-figure 13.



Modified spines of anterior four segments.

intermediary sclerites were thrown off, but it seemed impossible that the larva could be capable of throwing off the large lateral pharyngeal plates. No conclusive proof was obtained of the complete throwing-off of the second instar mouth-parts at the second moult, but this may be taken for granted as occurring as well as at the first moult.

The total larval life takes from 9 to 12 days. The minimum time observed was 8 days and the maximum 14 days. Eleven days is the usual length of time under laboratory conditions.

The total larval life and the ultimate size of the larva, and therefore the puparium, are controlled to a very large extent by the temperature and condition of the breeding medium. Lack of moisture is a very important factor. This explains the variety in size of the adults.

The Puparium.

At pupation the two anterior segments of the larva are withdrawn, bringing the anterior spiracles in a forward position. In this position the larval skin slowly changes to the brick-red colour characteristic of the puparium (text-fig. 14). The colour changes to black as the pupal period advances. It is more or less cigar-shaped; the anterior end is slightly flattened dorso-ventrally. The anterior spiracles can be seen as two dark projections at the anterior end. It measures from 6 mm. to over a centimetre in length. The size varies according to the conditions governing the life of the larva, mentioned earlier.

From larvæ bred in the laboratory a large percentage pupated in the hardened upper crust of the dung. This was probably due to the soil being too moist in the jars, as there was no outlet to allow the excess moisture to get away. Under ordinary conditions the soil is preferred, as in field observations very few puparia were observed in dung.

The pupal period takes from 10 to 17 days. The minimum time observed was 6 days and the maximum 18 days.

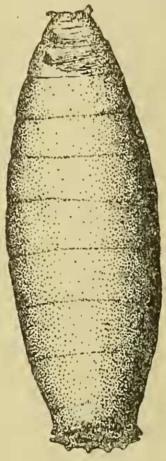
The following data give the comparative larval and pupal periods for a number of batches bred:—

Oviposition.	Egg.	I. instar	II. instar.	III. instar.	Pupa.	Total.	Emergence.
Jan. 5th.	48–54 hrs.	36 hrs.	36–60 hrs.	6–7 days.	6 days.	17–19 days.	Jan. 22–24.
Feb. 17th.	20–24 hrs.	36 hrs.	60 hrs.	6 days.	13–14 days.	24–25 days.	Mar. 12–13.
Mar. 1st.	36–42 hrs.	36 hrs.	36 hrs.	6–7 days.	9–10 days.	19–21 days.	Mar. 20–22.
Mar. 18th.	48 hrs.	36 hrs.	36 hrs.	9 days.	16–17 days.	30–31 days.	Apr. 17–18.
May 7th.	48 hrs.	36 hrs.	48 hrs.	7–8 days.	16 days.	28–30 days.	June 4–6.

The minimum time from adult to adult observed was 17 days and the maximum 31 days. The average time from the table given above is 24 days, but this time, as stated earlier, is governed by temperature and the consistency of breeding media.

In one batch of larvæ bred in dry dung the larvæ were observed to have collected in one spot where the only moisture was. These did not reach the third instar until after a week of larval life. They were transferred to fresh dung later, so that the total larval life was not observed. Under similar conditions the larval life may take as much as three times as long as the maximum observed.

Text-figure 14.



Puparium.

Sexual maturity is not reached until after 21 days of adult life. During this time the males have no attraction towards the females, and, owing to the male being the more robust, the latter are liable to be attacked unless a sufficient supply of food is maintained.

Copulation takes place about two days before oviposition. The life of the male is considerably longer than that of the female. No definite results were obtained on the life of the female. No females were observed to lay more than 120 eggs. It is probable that one female is capable of laying from 100 to 150 eggs and then dies. Eggs are laid in one batch of from 40 to 80 and afterwards, 10 or 20 at a time at intervals.

The total life-cycle from egg to egg takes from six to seven weeks.

Breeding takes place regularly from April to October, and there are probably five broods a year.

No definite results were obtained on hibernation, but evidently a large number hibernate as adults. A number of pupæ were exposed to cold weather during December, but the adults all emerged without exception. This implies that hibernation does not take place in the pupal stage, but it may be that the process of histogenesis had proceeded beyond a certain point before being placed in the cold, and the breaking down and building up of tissues in the pupæ were carried on. A large amount of adults are seen about on warm sunny days in winter, but 90 per cent. are males. I think that probably the majority hibernate as adults, but that only those females survive that failed to oviposit before the cold weather set in. This would account for the difference in proportion of the sexes. Probably a few survive the winter as puparia and the larger proportion as adults. Investigations extended over another winter would prove this point. Graham-Smith remarks that *S. stercoraria* hibernates as a resting larva or pupa in the soil, a few surviving the winter as adults.

A number of flies were placed in a glass-house heated by two electric radiators. During one night the temperature rose to over 90° F., with the result that they were all found dead the following morning. It appears from this that the fly is not capable of withstanding high temperatures. The fly is, however, a subtropical one as well as a temperate one, and should therefore be able to stand this temperature. The sudden change from a mild temperature to a hot one and the lack of ventilation were probably the cause. It must also be remarked that the flies were of a very large variety. The largest and smallest varieties are not so resistant to unfavourable conditions as the average sized varieties.

The food of the adults is very varied, but confined to other Diptera. The small Borborid fly (*Borborus equinus*) appears to be the chief article of diet in the field, chiefly as it breeds abundantly in horse excrement and as it passes the winter as an adult. Larger flies, however, are preyed upon, such as *Calliphora*, *Lucilia*, *M. domestica*, etc. Probably all species of Diptera are preyed upon, with the exception of those of fast flight, such as Syrphidæ and Stratiomyidæ. I observed, on one occasion, a large male attempt to capture a small dung-beetle (*Geotrupes*) as the latter was settling. At the Zoological Gardens in 1915 Professor Lefroy's experiments with fly-traps were interfered with by the abundance of the adult *S. stercoraria* that fed on the trapped flies, chiefly blow-flies of the genus *Calliphora*.

In summer the adults may be seen on plants and flowers far away from pastures waiting for other flies to settle in the vicinity.

M. domestica was used as food almost entirely in the laboratory, each fly sucking out as many as a dozen a day.

Natural Enemies.

Natural enemies were not observed. The Scarabeid and Staphylinid beetles and their larvæ, which breed in dung, do not appear to attack the larvæ of *Scatophaga.*

One Ichneumonid parasite was bred out from pupæ, but, having failed to reach the surface of the soil, was in too bad a state of preservation to be identified.

A large number of birds are mentioned by Newstead as feeding on Scarabeid beetles and Muscid larvæ breeding in dung, so that they very probably are a considerable check on the spread of *Scatophaga.*

A number of larvæ are probably destroyed by natural conditions such as the too rapid drying up of the dung or owing to the dung being trodden on and spread about by cattle.

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